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ON THE EXTERNAL MORPHOLOGY AND BIOLOGY OF *HETERONYCHUS SANCTAE-HELENAE* BLANCH. AND *METANASTES VULGIVAGUS* OLLIFF (COL., SCARABAEIDAE, DYNASTINAE).

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(Plate ix; twelve Text-figures.)

[Read 26th June, 1940.]

In the family Scarabaeidae of the Coleoptera, morphological work on the immature stages lags far behind taxonomic studies of the adults. By the "immature stages" is implied, in particular, the larval stages. Until fairly recently all Scarab larvae have been classed together in one group as "white curl-grubs" without serious attempt at specific differentiation. It is hardly necessary to point out that, in a group such as this where by far the greater part of the damage is caused by the larva, knowledge sufficient to permit immediate recognition of the larvae is invaluable. Adult damage is as a rule confined to the foliage of native trees, but that caused by the larvae includes a wide range of diverse plants. Illustrated morphological descriptions of various species of Queensland cane-beetle larvae have been published in some of the Bulletins of the Division of Entomology of the Queensland Bureau of Sugar Experiment Stations, but apart from these little work has been done in this direction in Australia.

Although work from the biological aspect has already been carried out on *Heteronychus sanctae-helenae* and *Metanastes vulgivagus* (for literature, see section dealing with life-history), knowledge of the external morphology of the immature stages is slight. In 1930 Burns published a short general description of the fully-fed third instar larva and of the pupa of *Metanastes vulgivagus*. In all stages the two species are similar in appearance as well as habits, which renders them easily confused. Such confusion has existed, and it was only recently that their identity in New South Wales as two separate species was established (Gurney, 1934). In the present paper are included descriptions of all stages of these species, with emphasis on the two destructive stages, the larval and the adult. It was considered advantageous to include a discussion of their bionomics, and also of the synonymy of *Metanastes vulgivagus*. These species are of particular interest, not only because of their comparatively short life-history, but because the adult is as a rule responsible for a greater amount of damage than the larvae.

Synonymy of Metanastes vulgivagus Olliff.

There has been in the past some confusion about the correct naming of this species. It was described by Blackburn in 1886 from South Australia under the name of *Pentodon australis*; in all the early literature and as recently as 1933 (McDougall, 1933) it is referred to as *Pentodon australis*. Olliff in 1889 recorded the same species from Lord Howe Island under the name of *Heteronychus vulgivagus*. In 1911 Arrow set up a new genus *Metanastes*, including two species,

Heteronychus australis Fauv., the type species from New Caledonia, and *Pentodon australis*. He suggested that the later described Australian insect (*Pentodon australis*) should be renamed *Metanastes blackburni*. It is the last name which appears in Gurney's paper of 1934, in which he discusses the synonymy of this species. Arrow later apparently decided that Olliff's original specific name should stand, as in the section on Dynastinae in the Catalogus Coleopterorum published in 1937, he uses the name *Metanastes vulgivagus* Olliff. The synonyms for this species are therefore *Pentodon australis* Blackburn, *Heteronychus vulgivagus* Olliff and *Metanastes blackburni* Arrow.

Economic History and Distribution.

Heteronychus sanctae-helenae Blanch. (*H. arator* Burm.—the black beetle) is an introduced pest species from South Africa, where it attacks maize and sugar-cane. Since 1930 it has spread rapidly in New South Wales and now occurs from the northern rivers south to Wollongong, in both coastal and inland districts. It was noted as a pest species in 1934 (Gurney, 1934), but had been causing appreciable damage four years prior to this. It has not been recorded in any State other than New South Wales as yet. This species is a major pest, attacking any lawn surfaces such as golf and bowling greens, also maize and sugar-cane, and vegetable crops such as cauliflowers and tomatoes; in addition it has been noted as attacking banana plantings and rose cuttings.

Metanastes vulgivagus Olliff (the black beetle, black set beetle, black stem gouger) is a native species first described from South Australia, where it is widely distributed, and also occurring in Lord Howe Island, New South Wales and Queensland. It ranks as a pest in the two latter States only. In New South Wales it was recorded as early as 1903 (Gurney, 1934), attacking maize seedlings at Richmond, and later as damaging sugar-cane in the Clarence River district, although the infestations were not heavy. There are few records of damage caused by *Metanastes vulgivagus* in New South Wales. In Queensland it attacks both maize and sugar-cane (recorded in 1912—Girault and Dodd, 1915), occurring as a minor and sporadic pest in practically all the sugar-growing districts of the State, but has not been recorded as a pest of other crops; at the present time it is not considered of considerable economic importance, although fairly extensive outbreaks have been reported (Gibson 1924, Mungomery 1927, 1929, Burns 1930).

Damage.

For these species it is invariably stated that the major part of the damage is caused by the adults, which attack in numbers the growing plants during the spring and early summer, boring into the stalk at any point beneath the surface of the ground. This results in a large ragged hole which, when the plant is young, will cause death; when the plant is older the boring action of the beetle, although it may not destroy a fatal amount of vascular tissue, will seriously weaken the plant.

Damage by the larvae of *Metanastes vulgivagus* has been reported. Burns (1930) states that in some instances as many as 4 and 5 final instar larvae of *M. vulgivagus* were found inside cane-sets; some had entered through the ends, while others had bored through the rind into the interior of the sets. Their tunnels may be several inches in length. The year previous to this, Mungomery stated that the larvae "ingest large quantities of soil and rotting vegetation before becoming full-grown, and it is from this rotting organic matter that they derive most of their nourishment. In addition to the beetles, these grubs are sometimes

responsible for injury to cane, and their chief damage consists of eating into the ends of cane sets and hollowing them out. Thus it will be seen that they are not essentially root-eaters". Jarvis (1927) stated that these larvae destroy the roots of cane sets, and gnaw big holes in the plants.

In no case has it been believed that damage was caused by larvae of *Heteronychus sanctae-helenae*. The question has been raised whether larvae of this species ever do attack the plant under field conditions, the usual assumption being that they can subsist upon decaying vegetable matter in the soil. This view is supported by the fact that all Scarab larvae ingest large quantities of soil, and probably do derive some nourishment from it. The writer, however, in March of the present year, observed a large area of turf (bent and couch grasses) in which the roots had been so completely destroyed that the turf could be pulled away in sheets from the ground. Immediately below was a heavy infestation of mature larvae of *Heteronychus sanctae-helenae*, together with pupae and recently emerged adults, some of which were not even completely darkened. There is no doubt that this damage was due to the larvae.

Under conditions in the insectary, larvae of both species (reared on maize) have been found to attack the grain both before and after germination, and the young shoots as well as the roots. Such extensive damage always results in the death of the plant. Preliminary experiments with *H. sanctae-helenae* and *M. vulgivagus* indicate that first and second instar larvae can exist upon what is derived from the soil alone. Experiments with *Euetheola rugiceps* Lec., a closely related North American species (Phillips and Fox, 1924), indicated that the normal food of the larvae consists chiefly of decayed and disintegrated vegetable matter, but this vegetable mould is consumed in inordinate amounts by the third instar larvae. It seems likely therefore that even if the normal food for all instars is decaying vegetable matter, where the supply of this in the soil is poor there will be insufficient for the voraciously-feeding third-instar larvae, and they will secondarily attack the living plants of their habitat.

In this connection the following facts are of interest. Fox and Ludwig (1937) stated that it had been possible to rear larvae of the Japanese beetle (*Popillia japonica*) from egg to adult on decayed vegetable matter alone, although in such instances development is somewhat retarded compared with that of larvae also supplied with other food, such as grains of wheat. In 1938 Fox and Ludwig published the results of a series of experiments with *Popillia japonica* larvae, in which they found that the suitability of the rearing medium used (decayed plant matter) appeared to be correlated with the taxonomic relationship to the grasses (Family Gramineae) of the plant furnishing this material. They further concluded that, since the addition of wheat or of yeast to a medium made it better for larval growth, these effects might possibly be due to the presence of accessory food factors belonging to the vitamin B complex.

Material and Methods.

The experimental and morphological work was carried out at the Zoology Department, University of Sydney, the field observations and collection of *Heteronychus sanctae-helenae* mainly at Moore Park, Sydney. Adults were also obtained from other Sydney localities, and from Broadwater, New South Wales. As a rule, they were hand-collected crawling on the ground surface between 7 and 9 a.m., in the months September to December. All adults of *Metanastes vulgivagus* used were collected at Harwood, and obtained through the kindness of the Colonial Sugar Refining Co., as were also those specimens of *Heteronychus*

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sanctae-helenae from Broadwater. Larvae, pupae and newly emerged adults of the latter were collected from the Royal Sydney Golf Club links in March. Like all Dynastids, these species breed well in captivity and because of their comparatively short life-cycle should be good subjects for experimentation on food preferences, etc.

The subsequent discussion refers to both species. The adults were kept in flower-pots filled with finely-sifted soil, and covered with cylindrical wire-gauze cages. The beetles fed readily on maize, either on the grain before germination, or on the young shoots. Copulation and oviposition took place normally. The soil was kept moderately moist; when examined for eggs it was passed through a fine sieve, and because of their white colour the eggs were readily detected. This frequent disturbance may have some effect on the total egg yield, but did not affect their deposition.

The eggs were transferred by means of a moist camel's hair brush to small pits in soil, impressed most satisfactorily by the blunt end of a pencil. The soil is packed firm, the hatching box being about two-thirds full. The containers used were tobacco tins, the lid conserving the moisture in the soil. Water may be added by means of a dropper. Excessive moisture is unfavourable, encouraging fungal growth. Hatching can be anticipated by the appearance of mandibles and spiracles through the egg membranes. When hatching took place the larvae were removed to flower-pots containing finely-sifted soil. They were buried in the soil, because, although capable of burrowing, they survive better if actually buried. The number of larvae to a 6-inch flower-pot should not be more than ten. Larval mortality in the stocks is invariably high and, in addition, if they are overcrowded they will attack each other. When the larvae were well into the second instar, they were transferred again to small cylindrical tins 2″ by 3″, one larva to each tin. To obtain the periods between moults, larvae were isolated from the time of hatching, in similar tins. The larvae are resistant to handling, but overwatering must be guarded against. It is much easier to overwater than underwater, and superfluous moisture will kill the larvae. The actual amount of water necessary is a matter of experience and varies according to external conditions. Some larvae were reared to the third instar in soil in which there were no growing plants, but subsequent to that they were provided with maize. When the prepupal stage was reached all plants were removed from the soil.

Life-History and Habits.

Because of marked similarity of life-history and habits the two species will be considered together. There is only one main generation every year. Both species overwinter in the soil as adults. The precise time of emergence is variable, this being governed by prevailing weather conditions. In 1939 adults of *Heteronychus sanctae-helenae* were collected in the middle of September. Mungomery (1929) records deposition of the first egg batches of *Metanastes vulgivagus* towards the end of August. At this time the adults may cause considerable damage. They have been observed on the wing swarming at lights during the evening; they are usually to be found crawling on the surface of the ground in the early morning after sunrise, disappearing as the sun's rays become hotter. This activity explains repeated infestation of crops from adjoining paspalum land; normally migration does not take place on the wing. They burrow either into the ground again, or beneath heaps of dead leaves or tufts of grass. These burrowing habits in *Heteronychus sanctae-helenae* are responsible for much uneven pitting

on smooth lawn surfaces such as golf or bowling greens and tennis courts (similar damage has not been reported for *Metanastes vulgivagus*). The preferred habitat of both species is low-lying paspalum pasture, and damage to crops is heaviest when plantings are made on recently turned paspalum land which is already infested (*Agric. Gaz. N.S.W.*, 1934–1939, *Qd. Agric. J.*, 1924–1930). Any subsequent lessening of infestation which may occur is probably explained by the fact that intensive cultivation, in addition to destroying any immature stages then present, eventually renders soil conditions unsuitable for the larvae.

Copulation occurs beneath the surface of the ground, and may take place some weeks before egg deposition by the female. Almost the entire life-cycle is spent in the ground: the adults feed, mate and oviposit, and the eggs, larvae and pupae develop below ground level. Copulation occurs throughout the egg-laying season: pairs in coitu were recovered as late as the middle of December, from individuals kept in the insectary. Egg deposition extends over a considerable period of time, under these conditions almost certainly longer than in the field. During the current season, 1939–40, females laid continuously, a few eggs at a time, from October till the end of February. Eggs of *Metanastes vulgivagus* in particular were found during the latter part of this period. Swarming frequently takes place again in March; the young adults will sometimes feed prior to hibernation in the soil, but egg deposition does not take place at this time. The total developmental period for both species is approximately the same, and remarkably short when compared with other Scarabaeidae, which require at least 12 months for their life-cycle. In *Metanastes vulgivagus* and *Heteronychus sanctae-helenae* the period from egg deposition to adult is 3 or 4 months. It is interesting to note that an American maize and sugar-cane pest, *Euetheola rugiceps* Lec. (subfamily Dynastinae) has a very similar life-history and habits, overwintering in the adult stage and requiring the same developmental period (Phillips and Fox, 1924).

The incubation period for the eggs is three weeks early in the season (October–November), decreasing to two weeks in December. The incubation period when the eggs are kept at a constant temperature of 80°F. is 10 days. The eggs are laid either freely in the ground, probably as the female is feeding, or enclosed loosely in a pellet of earth. The eggs of *Metanastes vulgivagus* are more often enclosed than free. The eggs are always laid singly a few inches below ground level, never in batches in a chamber in the soil, as with other species. The largest number of eggs deposited by a single female of *Heteronychus sanctae-helenae* under insectary conditions was 90, laid irregularly over a period of four months, from November till the end of February. The male died at the end of November, yet the female continued to produce fertile eggs.

The larvae start feeding soon after hatching. They ingest quantities of soil, so that the gut soon takes on the characteristic dark colour. They are active and capable of burrowing almost immediately. There are three larval instars. The first instar occupies a period of approximately three weeks, the second two weeks, and the third (including the prepupal period) about six weeks. When the final instar larva is fully grown it enters the quiescent prepupal stage, first forming a pupal cell in the soil, and discharging the contents of the rectum; during this period it is capable only of abdominal flexion, and is of a uniform pale colour. The pupa develops inside this larval skin, and in some cases development is completed within it, a dorsal split appearing when the pupa is fully formed. Generally the larval skin is shed completely. The pupal period lasts approximately a fortnight.

Adults of the new generation are a highly burnished black, those of the old generation are dull and readily distinguishable from the former. Most of the latter die before the end of the season, but Mungomery (1929) recorded adults of *Metanastes vulgivagus* producing, under laboratory conditions, eggs over two seasons at least.

Morphology.

a. Adult.

The two species are superficially very similar. They are both typical Dynastids, glossy-black dorsally and reddish-brown ventrally, but are easily distinguished by structural differences. *Metanastes vulgivagus* is slightly though distinctly larger; the length of this species is 14–16 mm. *Heteronychus sanctae-helenae* is 11–13 mm. in length, the males being slightly smaller than the females. The general shape of the two species is also rather different, the former being more broad and flattened than the latter. The obvious structural difference between the two species is the presence of two cephalic tubercles in the former species, and their absence in the latter. A second difference lies in the puncturation of the elytra. In *Metanastes vulgivagus* there are 7 impressed rows of punctures, without counting the most extreme median row in which the punctures are so deep that they form a striation. In *Heteronychus sanctae-helenae* there are 6 impressed rows. The presence or absence of the cephalic tubercles is the most reliable character, since the lengths are naturally very variable, and the elytral puncturation is also variable to a certain extent.

A striking feature common to both species is their sexual dimorphism. The male and female may be immediately differentiated by the shape of the fore tarsus. In the male the segments are shortened and flattened: one of the tarsal claws is simple, and the other is a broad bent lamina (Fig. 1). The tarsus of the female retains its normal filiform shape (Fig. 2): the deformity in the male is due to the use of the tarsi in copulation, the hooked tarsal claws being inserted beneath the elytra of the female. A less obvious sexual difference lies in the form of the pygidium, which in the male is broadly rounded and in the female is apically pointed.

b. Egg.

The eggs when freshly laid are elongate oval, almost oblong in shape. Swelling of the egg takes place almost immediately, doubtless due to absorption of water by the egg from the surrounding soil. At the end of three days there is quite marked swelling and the eggs have become almost spherical. ' There is a simultaneous increase along the major and minor axes; the total increase is greater along the minor axis. Several days prior to hatching the mandibles and spiracles of the young larva are visible through the chorion. For *Heteronychus sanctae-helenae* the chorion of the newly-laid egg is greyish-white in colour, sticky, shiny, and rather soft, with no markings except a faint pitting. The average size is 1·8 mm. in length and 1·3 mm. in width. Just before hatching the average length is 2·3 mm. and the average width 2·0 mm. The egg of *Metanastes vulgivagus* is appreciably larger, dead white in colour, and the chorion is tougher, but also without markings. The average size after laying is 2·3 mm. in length and 1·6 mm. in width. The average length before hatching is 2·8 mm. and the average width 2·4 mm.

c. Larva.

In general appearance the larva is typically scarabaeiform, creamy-white in colour except for the last two segments, which are black, due to the rectal contents showing through the thin integument. The general appearance of these larvae is too well known to need further comment. The hypognathous head is heavily chitinized with a well-differentiated epicranium and frons (Figs. 3, 4). The epistomal and clypeolabral sutures are quite heavily marked. The mandibles are reddish-brown, shading to black at the tips. The clypeus and labrum are slightly darker in colour than the rest of the head; the labrum is slightly asymmetric and not lobed. The chaetotaxy of the head is sparse. An oval stridulating area of transverse striae on the caudal side of the mandible (Fig. 5), and truncated stridulating teeth (the plectrum) on the cephalic side of the maxilla (Fig. 6) are present; these characters are postulated by Hayes (1929) as characteristic of the subfamily Dynastinae (see p. 44 of his monograph for discussion of the organs of stridulation). The larvae are supposed to emit sound by scraping one across the other. Dorsally each of the first six abdominal segments is divided into three subsegments, carrying short, stout, straight bristles together with a few scattered longer and more slender bristles. This dorsal chaetotaxy is only slightly variable and therefore has no systematic significance. The two regions of the body bearing important structural features are the head and the anal segment, the former including the epipharynx (Figs. 7 and 8; Plate ix, figs. 3, 4), and the latter the radula (Figs. 9 and 10), both of which have been found to be so variable that, taken in conjunction, they are valuable as a basis for the separation of genera and species, as has been shown by Hayes with North American species of Scarabaeidae.* His work was the first to demonstrate clearly the interesting and marked variations occurring in these two structures. The structure of the head capsule itself is also of diagnostic importance in some genera and species (Madle, 1935).

The radula is a specialized region situated ventrally on the anal segment of the body (Figs. 9 and 10), the function of which appears to be the cleaning of the mouth-parts. It occurs as arrangements of articulated bristles, which are very variable interspecifically. The radula is always considered in conjunction with the anal slit, which may be longitudinal, or transverse, that is, perpendicular to the longitudinal axis of the body. In both *Heteronychus sanctae-helenae* and *Metanastes vulgivagus* (Figs. 9 and 10) the anal slit is transverse, and immediately ventral to it is a clearly marked subanal flap, without a median series of differentiated bristles, agreeing with the characters for the subfamily Dynastinae set down by Subklew (1937). All bristles are articulated. The figures given for bristle numbers (see below) cover the most usual range found in these two species.

The epipharynx is a specialized sensory region, the membraneous inner wall of the labrum; in the descriptions of *Heteronychus sanctae-helenae* and *Metanastes vulgivagus* is also included a sensory area located on the inner wall of the clypeus (Figs. 7 and 8). This proximal sensory area is placed at the entrance to the pharynx and from its specialization is probably of considerable importance in perception of the nature of food ingested. It contains a rounded median tubercle, the sense cone, in which are visible four sensilla. On the right side of the sense cone (left in drawings) is present a pointed chitinous plate.

* The descriptive terms used are those of Hayes; see monograph of 1929 for account of epipharyngeal and radular variations in numerous species.

There are also present four clypeal sensilla and two groups of non-articulated clypeal hairs. The epipharynx is outlined proximally by the asymmetric tormae, which are heavily chitinized bars at the lateral extremes of the clypeolabral suture, the right long and narrow, tapering to a point just distal of the chitinous plate, the left very slightly curved and ending bluntly. There are also present lateral and median articulated setae, the latter surrounding a median bare space. The lateral setae are curved and fairly long, without striae at their bases (such as occur in larval Melolonthinae); and increase in size towards the distal series of relatively long and straight bristles. The number of bristles present in the epipharynx of either species is unimportant. The two species agree in all the points just outlined; the feature distinguishing *Metanastes vulgivagus* from *Heteronychus sanctae-helenae* is the shape of the distal sensory area (see below). The distal sensory area is located above the median bare space, and (within the family Scarabaeidae) may include various spines or bristles and sensilla, and is evidently a localized perceptive region. Epipharyngeal studies were carried out on specimens both before and after clearing. The drawings (Figs. 7, 8) and photographs (Plate ix, figs. 3, 4) were taken from Canada balsam mounts.

Comparative Morphology of the Larva.

Distinguishing features of Heteronychus sanctae-helenae *and* Metanastes vulgivagus.

These descriptions of epipharynx and radula are based on final instar larvae, since there is little difference in regard to these structures between the instars and within each species other than an increase in size, and a fairly marked increase both in thickness and number of bristles from first to third instar. Both structures are therefore described in the fully-developed condition. In the first two instars, although not completely developed, these diagnostic features are still quite sufficiently distinctive. The colour of the head capsule (and its puncturation in *Metanastes vulgivagus*) does not change, and was actually found an adequate character for separation of the two species in experimental work.

1. *Heteronychus sanctae-helenae.*

The average width of the head capsule of a first-instar larva (measured at the antennal bases) is 1·5 mm.; of a second instar larva is 2·4 mm.; the length of a fully-fed final instar larva is about 25 mm. (when extended as in the crawling position), and the average width of the head capsule 4 mm.

The head is light-brown in colour, and very finely reticulated, appearing smooth to the naked eye (Plate ix, fig. 2). It has a few scattered punctures on the frons, clypeus and labrum. On the frons are 14–20 short and long bristles (Fig. 4), not including the 2–3 bristles situated on each side of the head between the antennal bases and the articulation of the mandibles. The disposition of these frontal bristles varies.

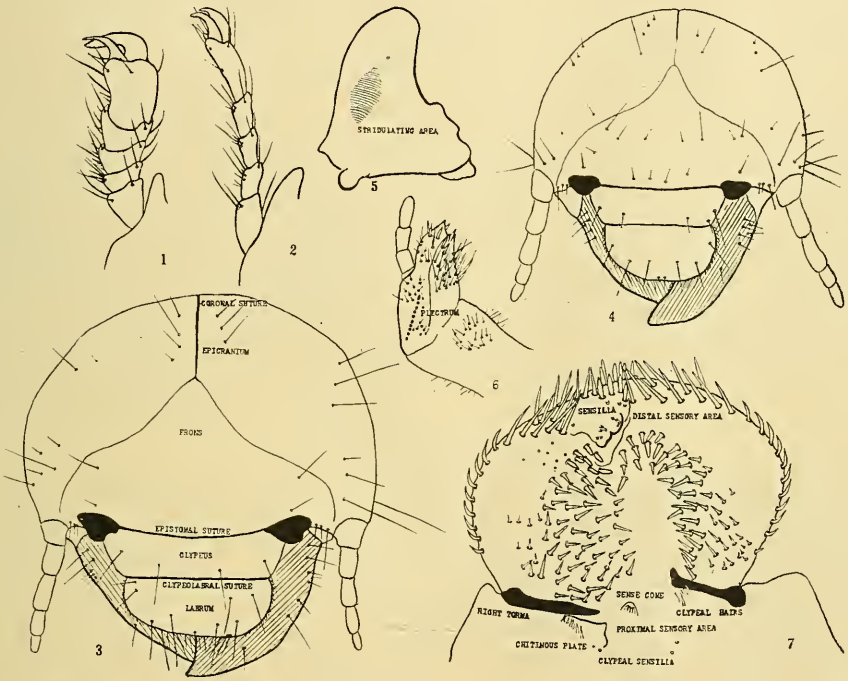
The distal sensory area is a humped chitinous area ending in a single large projection directed proximally, without teeth or spines, but bearing on the right (left in drawings) a group of closely set stout bristles. This projection is usually bifid, and may be trifid. The bristles at the apex of the epipharynx are short and thick (Fig. 7).

The subanal flap carries, on the lower lip of the anus, a row of about 12 long fine bristles (Fig. 9); the rest of the area is occupied by 35–40 shorter and stouter bristles. Dorsal to the anus is a longitudinal bare space, and on either side of this a patch of 20–25 short straight bristles and, laterally, groups of

longer and finer ones. Ventral to the subanal flap is a small group of 20–25 short stout bristles, with two rather larger than the rest, and 2–5 long fine bristles. In this species no bristles are hooked.

2. *Metanastes vulgivagus.*

The average width of the head capsule of a first instar larva is 2·1 mm.; of a second instar larva is 3·5 mm.; the length of a fully-fed final instar larva is about 30 mm., and the average width of the head capsule 5·5 mm.



Figs. 1-2.—*Heteronychus sanctae-helenae.* 1, Adult male fore tarsus; 2, adult female fore tarsus.

Fig. 3.—*Metanastes vulgivagus.* Head capsule of third-instar larva, showing frontal chaetotaxy.

Figs. 4-7.—*Heteronychus sanctae-helenae.* 4, Head capsule of third-instar larva, showing frontal chaetotaxy; 5, mandible, showing oval stridulating area; 6, maxilla, showing plectrum; 7, epipharynx.

The head is reddish-brown in colour, quite distinctly darker than *Heteronychus sanctae-helenae*; the coronal suture is darker than the rest of the epicranial suture (Fig. 3). On the frons there are four long bristles only (not including the 2–3 pairs between the antennal bases and the mandibular articulations) in contradistinction to the 14–20 long and short bristles on the frons of *Heteronychus sanctae-helenae.* The head is finely reticulated and deeply and closely punctate (Plate ix, fig. 1). The four points on which the two species differ in regard to the external morphology of the head are size, colour, frontal chaetotaxy and puncturation.

The distal sensory area is a curved chitinous area projecting proximally as three large teeth. The difference between the two species is obvious on comparison (Figs. 7, 8).

The subanal flap carries along the lower lip of the anus 20–25 short and long straight bristles (Fig. 10); the rest of the area is occupied by 30–35 curved (many hooked) and stout bristles, more or less evenly spaced. The longitudinal bare space, dorsal to the anus, seen in *Heteronychus sanctae-helenae*, is missing; the chaetotaxy in this region consists of mixed short and long bristles, most of which are slightly curved. Ventral to the subanal flap are 40–50 hooked stout bristles with 3 or 4 long bristles among them, and laterally long and slender slightly curved bristles.

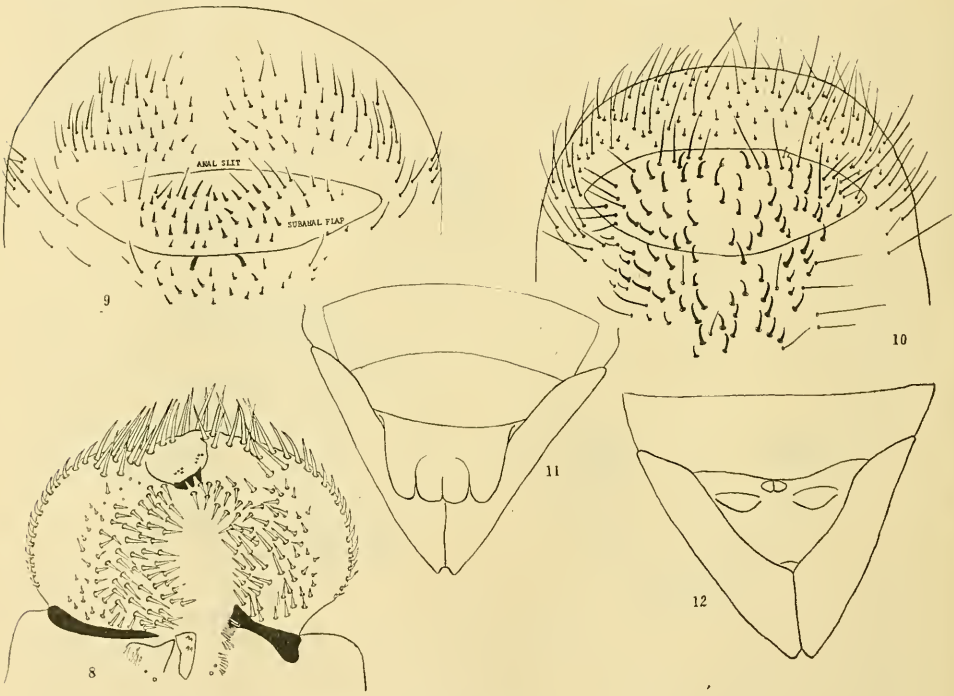


Fig. 8.—*Metanastes vulgivagus*. Epipharynx.
Fig. 9.—*Heteronychus sanctae-helenae*. Radula.
Fig. 10.—*Metanastes vulgivagus*. Radula.
Figs. 11-12.—*Heteronychus sanctae-helenae*. 11, Male pupa (terminal segments, showing genitalia); 12, female pupa.

d. Pupa.

The length of the pupa of *Heteronychus sanctae-helenae* is approximately 15 mm., of *Metanastes vulgivagus* is approximately 20 mm. In both species the pupa is exarate, the typical form of the Coleoptera, and is capable of abdominal movement only. When the larval skin is first cast off, the pupa is a uniform pale yellow, but before emergence of the adult the pronotum, head, legs and terminal abdominal segments become reddish-brown in colour. At this time the organization of the adult form is distinctly visible through the pupal integument. Male and

female pupae are easily differentiated by the general shape, the male (Fig. 11) as a rule with a more elongate and slender abdomen than the female (Fig. 12), by the fore tarsus, and by the genitalia. The fore tarsus of the male is much thicker and shorter than that of the female, because of the deformed tarsus of the adult male. The genitalia of the male are clearly seen with the naked eye at the end of the abdomen. At the time of emergence the elytra are pale, and darkening of the whole body occupies a considerable time. The adult, in fact, remains reddish-brown for some days, and while in this stage may easily be mistaken for a different species.

Summary.

In spite of the apparent close resemblance between *Heteronychus sanctae-helenae* and *Metanastes vulgivagus*, both in appearance and habits, in the two destructive stages, the larva and the adult, these species are readily distinguished by their external morphology. Since damage can only be caused when either the larvae or the adults are active, it is actually sufficient to possess knowledge only of differential diagnostic characters for these stages. Such characters have been described. It is considered that the morphological section of this paper is the more important, and it is hoped that the work will be in the future extended to include other common economic species of Scarabaeidae. In parts the morphological description of the larvae is deliberately made general, so that it is applicable to the family as a whole—relevant to this object. The discussion of the biology of *Metanastes vulgivagus* and *Heteronychus sanctae-helenae* was included for the sake of completeness, since bionomical work on both species has previously been carried out and the results published.

Acknowledgements.

The writer is indebted to the Colonial Sugar Refining Co. Ltd. for supplying material; to Professor E. G. Waterhouse and Mr. W. Hazlewood for their assistance in obtaining specimens of *Heteronychus sanctae-helenae*; to Mr. R. W. Mungomery and Mr. W. McDougall of Queensland for information concerning the distribution and synonymy of *Metanastes vulgivagus*; to the Secretary and staff of the Royal Sydney Golf Club, through whose assistance interesting material and information were obtained; and to Mr. A. R. Woodhill for helpful criticism. She also wishes to thank particularly Mr. F. H. Taylor for his unfailing interest and help, and for the photographs embodied in Plate ix.

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EXPLANATION OF PLATE IX.

1.—*Metanastes vulgivagus*. Head capsule of third-instar larva, showing puncturation.
2.—*Heteronychus sanctae-helenae*. Head capsule of third-instar larva, head smooth.
3.—*Heteronychus sanctae-helenae*. Epipharynx.
4.—*Metanastes vulgivagus*. Epipharynx.